

STATE-OF-THE-ART NEAR-FIELD MEASUREMENT SYSTEM

*Antenna Measurement Techniques Association Conference
November 13-17, 1995*

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ABSTRACT

Planar near-field measurements are the usual choice when testing phased array antennas. NSI recently delivered a large state-of-the-art near-field measurement system for testing a multi-beam, solid state phased-array antenna. The critical sidelobe and beam pointing accuracy specifications for the antenna required that special attention be paid to near-field system design. The RF path to the moving probe was implemented using a multiple rotary joint system to minimize phase errors. Additional techniques used to minimize system errors were an optical probe position correction system and a Motion Tracking Interferometer (MTI) for thermal drift correction.

1. INTRODUCTION

Planar near-field testing offers several advantages over far-field testing of large array antennas. They are:

- Minimal real-estate requirements.
- Lower cost than a compact range.
- High accuracy and high test throughput.
- Use of hologram back projections for diagnostic purposes.
- No AUT movement

In order to properly design a near-field test system which will minimize cost and satisfy all measurement requirements a thorough understanding of near-field concepts and measurement errors must be had. The design goals for this system were:

- High sidelobe and beam pointing accuracy.
- Multi-frequency, multiple beam testing.
- High volume production testing capability.

- Ability to network with the customers antenna control computer.
- The design of a near-field range capable of meeting these specifications requires minimizing the measurement errors through the design of near-field measurement subsystems: Scanner, RF receiver, RF cabling, RF absorber and Environmental control.

The careful tradeoff between subsystem components, error measurement and active compensation is the key to minimizing cost while meeting measurement accuracy. The design and use of error compensation schemes is an evolving process and is one of the most important aspects of this paper

2. DESIGN CONSIDERATIONS

Table 1 summarizes a few selected design specifications for this system. Often high accuracy requirements on subsystems can be traded off for active error monitoring and compensation. To obtain the accuracy required for this state-of-the-art system all three aspects of the design were used:

- Highly accurate subsystems.
- Error monitoring
- Dynamic and passive compensation

Scanner Design

The probe positioning system is a highly accurate design which includes design considerations to control thermal and seismic errors. The scanner is an inverted-T design with a granite base and a thermally compensating steel

tower. The scanner is oriented vertically and has a scan area of 23 ft (X) by 12 ft (Y).

Rf Receiver/Probe

The RF receiver is a Hewlett Packard 8530A receiver. It was selected because of its high performance, and excellent reliability. A dual source external mixer configuration was chosen to provide high speed multiple frequency operation and minimize errors when using long cable paths.

A low gain dual-polarized probe was selected to reduce probe compensation at wide AUT scan angles. The dual polarization probe reduced measurement time through the use of signal multiplexing. The probes were calibrated by NIST for patterns and gain. This is an important consideration because gain calibration reduces measurement time since the gain of the AUT can be determined with a single scan as opposed to gain-comparison to a standard gain horn which requires two scans and increases measurement errors.

RF Cabling

Low coefficient of thermal expansion (CTFE) cables were selected to minimize thermal variations in long cable runs. In addition, an articulated arm was designed using fixed cables and rotary joints which provides low phase variation without restricting bandwidth as in articulated waveguide arm systems.

RF Absorber

The chamber and scanner were designed to accommodate the large AUT, and to minimize multipath to the antenna. Special attention was given to reducing multipath from the tower structure and probe by placing absorber walls at varying angles to the incident energy. Tradeoffs were made based on apriori knowledge of AUT scan angles relative to the scanner.

Environmental Control

NSI did not have responsibility over the chamber's thermal control but did work directly with the customer to identify requirements

through analysis and test. As is often the case the customer originally had relatively poor thermal control. During the design phase new goals were set for this control and a relatively inexpensive arrangement of sensors and controls allowed the temperature and thermal gradients to be controlled even during AUT transmit operations.

3. ERROR MONITORING

Three techniques were used for error monitoring of the various subsystems: Laser probe position tracking⁽¹⁾, Motion tracking interferometer⁽²⁾, and Multi-Z error measurement⁽³⁾. The use of these systems determines the accuracy of the uncompensated systems described in Section 2 and identifies the compensation to be used as described in Section 3.

Laser-Probe Position Tracking

This system provides both high resolution X/Y position data using laser interferometers and probe X, Y, and Z errors. X/Y error measurements are made with a device which tracks the laser beam wander on the laser receiver and converts it to $X_{error}(Y)$ and $Y_{error}(X)$. A spinning plane laser and probe mounted sensor are used to derive probe Z errors. The outputs from these devices are input to the software for real-time error correction.

Motion Tracking Interferometer- MTI

NSI's motion tracking interferometer is used to measure RF receiver, cable, scanner and AUT structure drifts caused by residual thermal variations in the facility. This patented technique offers an inexpensive method of accurately monitoring errors during the test by making a series of repeated RF measurements over time.

Multi-Z Measurements

Multiple measurements with varying probe separation in the Z-axis are used to identify and reduce multipath effects of the probe. A computer-controlled probe Z-axis was designed to automate the process.

4. DYNAMIC AND ACTIVE COMPENSATION

During probe scanning in one-axis, small errors occur in the orthogonal (cross) axes due to imperfect mechanical fabrication. When these are monitored with the techniques described in Section 2 it is then possible to dynamically compensate the probe position during scanning or adjust the data prior to processing. All this is done with a PC-based system.

COMPUTER EQUIPMENT

Two identical computer were provided for data acquisition and analysis, the second allows simultaneous off-line data processing. The two computers were networked together along with the customers antenna control computer. The computer's task were:

- Control probe positioning, beam multiplexing and triggering
- Monitor and Compensate for cross-axis errors
- Control HP receiver hardware
- Interface to customer's beam steering computer
- Monitor thermal environmental errors

5. SUMMARY

This system represents the state-of-the-art in near-field test ranges. Its combination of a highly accurate subsystem design, error monitoring and dynamic and pre-processing correction provide the highest possible accuracy available.

REFERENCES

1. Position Correction on a Large Near-Field Scanners Using an Optical Tracking System, By Greg Hindman, Antenna Measurements Techniques Association (AMTA) October, 1994
2. Thermal Error Corrections in Near-Field Measurements, by Greg Hindman, Dan Slater, Antenna Measurements Techniques Association (AMTA) October, 1995

3. Error Suppression Techniques For Nearfield Measurements By Greg Hindman, Antenna Measurements Techniques Association (AMTA) October, 1989

Table 1. Selected design specifications

Design specification	Subsystem components	Error monitoring	Compensation technique
Probe tip accuracy: X,Y, Z 0.001 mil RMS	Scanner	Laser probe tracking	Dynamic probe positioning
Array phase accuracy 1.0 deg RMS	RF receiver RF cabling RF absorber Environmental control	MTI Multi-Z	Data pre-processing

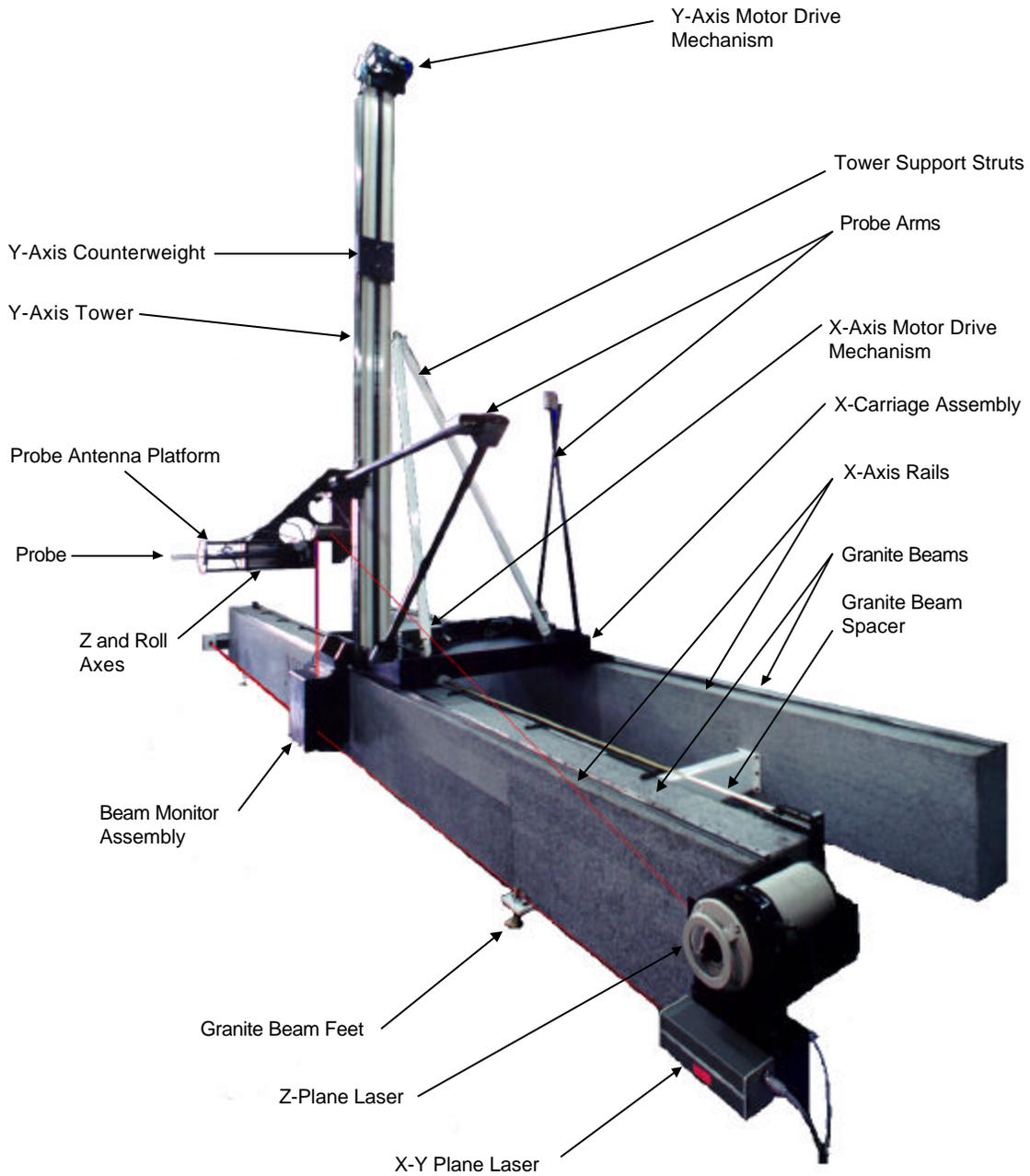


Figure 1 State-Of-The-Art Near-field Measurement System